PLEASE KEEP WITH
INSTRUCTION MANUAL

SHORT FORM OPERATIONS MANUAL FOR 660B

Nicolet

F O R W A R D

This manual provides operating instructions for the Model 660B Dual-Channel FFT Processor. These instructions introduce the Model 660B controls on a function-group/by/function-group basis. The order of control introduction follows the flow of selections in normal operation. It is recommended that these instructions be read in their entirety before attempting to operate the equipment. For those users who may already be familiar with this equipment a Short Form Operations Manual directly follows.

SHORT FORM OPERATIONS MANUAL FOR 660B

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G-1. INITIAL SETUP (GETTING STARTED)

A. Be sure the FREQ/ORDERS switch is set to FREQ (internal sampling clock), the coupling switch to AC or DC, and the polartiy switches to normal or invert. Be sure you are not in HOLD.

B. Choose MODE--Most common will be Dual 1K which means that 1024 time samples will be taken from both Channels A and B. These will yield two 400 line spectra (other modes are discussed below in Section E).

C. Connect input signals to Channels A and B inputs and reduce MAX AMPLITUDE controls to most sensitive value which does not light overload lights.

D. Set FREQUENCY RANGE. Start high to ensure data is not missed.

G-2. SET CAPTURE CONTROL (GETTING READY TO COLLECT DATA)

A. CONTinuous for random, sinusoidal, or machinery vibration (Hanning^2 ($\cos^4$) window is used).

B. TRANsient for transient or impulsive input (flat weighting is used).

C. ARM is used to trigger on transients.

D. HOLD/REL manually stops data sampling. Pressing HOLD/REL a second time either resets the ARM or starts continuous sampling.

E. TRIG LEVEL sets the level of the trigger when in the ARM mode.

G-3. COMMONLY USED FUNCTIONS (DUAL CHANNEL 1K FFT MODE)

A. INPT TIME displays 1024 time points of each channel for 1K mode and single 2048 point time trace for 2K analysis. This function is particularly useful for observing transients.

B. INSTantaneous SPECtrum displays each spectrum of Channel A, Channel B, or both as they are computed. When HOLD is depressed, the sampling stops and the spectrum displayed is the spectrum of the last time window. Vertical units are volts.

C. RMS SPECtrum displays the averaged spectra of Channels A and/or B. This only functions during and after averaging. Vertical units are volts.

D. Power Spectrum--Same as RMS spec but vertical units are V^2.

E. Transmissability--Channel B magnitude divided by Channel A magnitude, that is, real ratio of output power spectrum to input power spectrum.

F. TF--(Transfer Function) displays during and after averaging the frequency response function B/A ($j\omega$) in any of the display formats discussed in the next section.

G. COHerence displays the coherence function between Channels A and B for averaged transfer functions. The coherence function is a real valued function from 0 to 1.0 which indicates the linear causality from input to output. Coherence of 1.0 is perfect. Coherence less than 1.0 indicates there are other system excitations or noise on either the input or output signal, or the system is nonlinear.

H. Impulse Response--IFFT of transfer function--what the response of a system would be to an impulse assuming A = input and B = output of the system.

G-4. AVERAGE (CONTROLS THE AVERAGING MODE)

A. SUM--Can compute from N = 1 to 9999 spectrum averages. The default number is 16 and may be changed by depressing the following keys on the CALCULATION CONTROL: The number of averages N, SET/STORE, AVGN.

B. DIFF subtracts N spectra from a previous average.

C. EXponential is similar to RC averaging and continually updates data. The effective RC time constant is T = N TIME WINDOWS (sec), where N is Avg N.

D. PK saves the maximum amplitude of each frequency window during spectrum averages.

E. SWEEP averages with maximum overlap or maximum redundancy--normally not used.

F. TRAN averages spectra of N transients automatically in SUM, DIFF, EX, or PK modes. It automatically selects a FLAT window and rearms the capture control after each inut. Signals which overload the input are automatically rejected.

G. START erases the memory and averages until N averages are taken.

H. STOP halts averaging.

I. CONT resumes averaging until N is reached.

G-5. DISPLAY FORMATS
(See Tables 9-1 AND 9-2 for applicable functions.)

A. Channel:

1) A--Channel A only

2) B--Channel B only

3) A/B--Channels A and B

B. Formats:

1) NYQuist--A cross plot of Real and Imaginary components which indicates a polar plot of frequency response or "orbit diagram." (Be sure to set vertical and horizontal display scales to the same range by turning CURSOR OFF and adjusting GAIN toggles.)

2) X PROP--Automatically selected for functions which are two channel cross properties.

3) REAL, IMAG, R/I, REAL and/or IMAGinary components of cross spectra and transfer functions.

4) MAG, ϕ, MAG ϕ, Magnitude and/or phase angle of a cross spectrum or transfer function.

G-6. DISPLAY MEMORY

A. STOre retains one 800 line spectrum, one 1024 t time waveform, or two 400 line spectra. For the display of cross-spectrum or TF, stores REAL and IMAG terms regardless of display.

B. ReCalL displays stored data when LED is on. Pressing a second time reverts back to current display (LED off).

C. COMP displays one stored trace and corresponding current trace if both processed in a similar manner.

D. EQL TF/TM divides current spectrum magnitude by stored spectrum magnitude and subtracts the stored phaseangle from the current angle. Also equalizes impulse response and transmissibility. This allows effects introduced by imperfect transducers to be gotten rid of. (Performs complex divisions.)

G-7. OUTPUT DISPLAY CONTROLS AND FEATURES (INCLUDES AN EXPLANATION OF EACH DISPLAY ANNOTATION FIELD)

A. Scales--Selects linear or log amplitude and linear or log amplitude and linear or log frequency. Scales are fixed for coherence (0-1).

B. Display GAIN toggle switches.

1) UP raises trace.

2) DOWN lowers trace.

Use upper toggle switch for upper trace of all dual traces except ϕ/MAG where this switch controls MAGnitude.* Upper toggle controls gain of all single trace displays and horizontal scale of NYQ display.

C. Amplitude units--This section determines the units of spectrum data during CURSOR readout.

1) dB/LIN--Either dB or Linear scale on vertical axis.

2) V/EU--Vertical axix labeled in volts per division or in engineering units (see calculation control).

3) ABS/REL--ABS reads absolute amplitude at the CURSOR. REL gives the relative amplitude between two CURSOR locations (see calc. control).

4) PER Hz--Used for Power Spectrum only.

D. CURSOR Type

1) OFF--no CURSOR--full scale amplitudes are annotated on the display.

2) Single--normally used--amplitudes at CURSOR are annotated on display.

3) Harmonic--all multitudes of CURSOR position will be brightened on the display.

E. Display notation (see attached displays)

1) A--Error messages, keyboard entries and settings (number of averages, delay times, etc.).

2) B--CURSOR position on the horizontal axis,

* 660B: When viewing phase only, single or dual trace, upper trace controls phase center, lower trace controls expansion.

normally seconds in time domain, Hz in frequency domain. (See Table 13-1 for other possibilities.)

3) C--Vertical amplitudes at the CURSOR for the upper and lower plots, respectively or when CURSOR is turned off, the full scale range of upper and lower channels.

4) D--Vertical scale - VLG = Log, VLN = Linear

5) E--Capture control settings C--CONT, T--TRAN

6) F--Top display trace channel and format: possible formats R--REAL, P--Phase, M--Magnitude, I--IMAGinary. Channel does not appear for Cross Prop's like TF.

7) G--Type of averaging and number of averages. SU = SUM, PK = PEAK, EX = EXponential, DF = Difference, SW = SWEEP, T in front of the other abbreviations indicates Transient averaging, i.e., TSU, TPK, etc.

8) H--Function type, see Table 9-1 for all abbreviations. TF = Transfer function, RS = RMS spectrum, COH = Coherence, IT = Instantaneous time, E prefix = Equalization, D postfix = Density.

9) I--Same as F only for lower trace.

10) J--Max Amplitude setting for Channels A and B respectively. D = DC, A = AC, T = Test.

11) K--Transient trigger source and level, i.e., A/16 = Channel A at FS/16.

12) L = Horizontal scale units.

13) M--Horizontal full scale.

G-8. CALCULATION CONTROL FEATURES (GENERAL INTRODUCTION AND FIFTEEN MAJOR USES)

A. General--Settings are always made in the following order:

1) Enter number.

2) Depress SET/STORE.

3) Depress appropriate panel button.

B. To recall or annotate a setting

1) Enter number.

2) Depress RECALL.

3) Depress appropriate panel button.

C. In order to

1) Change number of averages: enter number of averages, press SET/STORE, press AVGN. The number of averages will appear in display position A.

2) View number of averages: press RECALL, AVGN

a) when not averaging, shows setting

b) when averaging, shows number of averages completed.

3) Saving CURSOR location--good when you wish to return often to a specific frequency. Enter number from 1-9, press SET/STORE, and CUR LOC. To recall CURSOR, enter number from 1-9, press RECALL and CUR LOC.

4) Store panel settings--even after machine is turned off. A total of 9 panel settings can be stored, enter 1-9, press SET/STORE, press PNL--Beware: The frequency range and input max amplitudes will be those stored in panel, not those set on analyzer. Just rotate the amplitude and frequency knobs to change.

5) Locate the leading edge of a transient in any location in the time window. Enter--number (-1.000 to 63.000) where the three decimal numbers are the fraction of th total window. If you want the transient at the 10% location, Depress: -.100, SET/STORE, DLYT → A. Showing later time greater than the first memory period may be determined by entering up to 63 memory periods of delay. Use RECALL to read number being used.

6) To set time delay between Ch A and Ch B, the capture procedure is similar to the above only positive numbers from 0.000 to 64.000 are available.

7) Measure and display in engineering units--set display so only the channel being set is viewed,

i.e., either Ch A or Ch B. Enter number of volts/engineering unit, press SET/STORE, press V/EU to establish setting. To enter value at CURSOR as calibration in engineering units, enter number, press SET/STORE and LIN. The amplitude units buttons determine which settings are applied.

8) Use the Zoom FFT for Frequency expansion--enter desired Bandwidth on keyboard, press SET, XPND WiDTH. Enter center frequency on keyboard, press SET, XPND.

Possible expansion ratios are 8, 16, 32, 63, 125, 250, and 500. Any number may be entered, but the analyzer will always go to the next lowest of the above numbers.

Both XPND and XPND WiDTH are cleared with the CLEAR button. (To expand around the CURSOR, press CLEAR, SET, XPND. The CURSOR frequency will be used as the center frequency.)

When the XPND is activated, the upper and lower frequency limits of the expansion window are annotated in the upper left of the display. Pressing RECALL, XPND will recreate this annotation if the expander is on. If the expander is not on, RECALL, XPND will turn it on using the same center frequency as the last expansion used.

For further information, see pages D1-D5 in the back of the 660 Manual.

9) Set calibration at CURSOR to a known dB level; enter no. of dB, press SET/STORE, dB.

10) Calculate RMS Power between two frequencies:

a) View RMS Spectrum.

b) Put CURSOR on 1st frequency and press 1, SET, CUR LOC.

c) Put CURSOR on 2nd frequency and press 2, SET, CUR LOC.

d) Press CLEAR, RECALL, RMS 1→2.

Notes:

a) You may use other stored CURSOR locations than 1 and 2. If the two frequencies are stored CURSORS 5 and 8 for example, press 58, RECALL, RMS 1→2.

b) The power at the limit cells is included in the computation.

c) If you are viewing a power function (power spec, cross spec, coherent output power) then RMS 1→2 calculates mean-square power, not root mean square power. Take square root to get RMS.

11) Pseudo integration and differentiation--mainly used to compute velocity and displacement from acceleration--only works in the frequency domain. Multiplies amplitude by $1/\omega$ or $1/\omega^2$ when integrating.

Enter number of integrations or derivatives (0, 1, or 2), press SET, and either ∫dt or d/dt. The number of integrations or derivatives can be found by pressing RECALL, ∫dt or d/dt.

12) Coherence Blanking--results in blanking of all transfer function data when coherence value is below a given level.
To set level, enter number from .000 to.999, press SET/STORE, COH BLaNK.

a) To view level, press RECALL, COH BLaNK.

b) To remove, press CLEAR, COH BLaNK.

13) Range of Log (dB) display--enter total range (20 to 160 in 20s), press SET/STORE, DSPL dB. Can be checked with RECALL and deleted with CLEAR.

14) Read frequency relative to a reference--place CURSOR at reference frequency and enter a reference number (0 to 10^5), press SET/STORE, FREQ REF. All subsequent frequency readings at the CURSOR will add the reference number.

15) Read multiples of a reference frequency--locate CURSOR and enter its multiple to reference (number from .0001 to 99.9999) and press SET/STORE, ORD REF. All subsequenct frequency readings at the CURSOR will be multiples of the set reference order. IF the frequency reads switch is in the ORDERS position.

G-9. OTHER 660 FEATURES

A. Digital Plots

Exactly what you see on the 660's display can be reproduced on a Nicolet 136A or Tektronix 4662 Digital Plotter.

1) Connect the plotter to the 660 using the RS-232C Interface.

2) Make sure baud rates and parity settings match. (See Figure 19-1 for setting these parameters in the 660.)

3) Press 1, SET, DEF AUX. (This is the default state.)

4) Set upper right and lower left on your plotter. (You may use "AUX, PLOT CAL" to find graticule corners.)

5) Press AUX, PLOT.

Only the last step is necessary to start each plot. The first three are set up.

B. Order normalization (order tracking):

If a machine changes speed while the 660 is averaging it's spectrum, the spectrum will be smeared. This smearing is eliminated when the 660 sampling speed is proportional to the machine's speed. To accomplish this (called order tracking):

1) Set the FREQ/ORDERS switch to ORDERS.

2) Connect a tachometer's pulse output to the 660's ORDERS INPUT. The highest order on the display will be (# pulses per revolution/2.56).

Note:

When the FREQ/ORDERS switch is in the ORDERS position the 660 takes one sample for each pulse on the ORDERS INPUT connector. The internal sampling clock is disabled. If there are no pulses coming in, the 660 will appear dead.

To make the cursor annotation correctly read orders

1) Set the FREQ READS switch to ORDERS.

2) Put the cursor at a known point on the horizontal axis (for example, the rightmost cell = # pulses per revolution/2.56).

3) Enter the known value and press SET, ORD REF.

For example, if the tachometer puts out 32 pulses per machine revolution, the rightmost displayed cell is 12.5 orders. So, with the CURSOR on the rightmost cell, you would press 12.5 SET, ORD REF.

The CURSOR position will now be correctly annotated in ORDERS.

Warning:
The frequency range switch selects the anti-aliasing filter. Be sure to pick the correct range. For example, if your tachometer outputs 32 pulses per machine revolution, and the machine will rotate at approximately 2000 RPM, the 660 will take 2000 x 32 = 64,000 samples per minute = 1067 samples per second. The frequency range (= anti-aliasing filter) selected should be less than or equal to 1067/2.56 = 417. So in this case, the 200 Hz range would be used. Use of a higher range will cause aliasing. The antialiasing filters are -3dB at frequency range +10%, so data above order 6 (200/417 x 12.5 orders = 6 orders) will be attenuated. If you are going to be doing a great deal of order tracking, or if you expect the machine speed to vary greatly, yu will need Nicolet's Model 24C Spectrum Tracking Adapter with its optional Tracking Anti-Aliasing filter.

G-10. OTHER 660 MODES (BESIDES 1K FFT)

Below, the 660 modes will be discussed (other than Dual 1K, which has already been discussed).

A. SIG ENH (Signal Enhancement Mode):
In this mode, the time histories are averaged instead of frequency spectra. Time averaging must be done synchronously (i.e., triggered by the capture controls). Signals that are not synchronized with the trigger will eventually average to zero, while signals that are synchronized with the trigger will add constructively with each average. This can be useful for seeing frequency components of a machine's spectrum that are multiples of the shaft speed. Without time averaging, these signals may be masked by non-periodic disturbances.

Note:
A relatively large number of averages may be required to significantly enhance the periodic signals.

1) Functions available in this mode:
Instant Time, Averaged Time, and Averaged Time Spectrum (INST SPEC button).

2) Averager modes available in this mode:
Summation (usually used), Difference, Exponential; with TRAN modifier.

B. Channel A 2K FFT Mode:

In this mode, the 660 functions as a single channel analyzer with twice its usual baseband resolution: time histories are 2048 points, a spectrum contains 800 points.

1) Functions available in this mode:
Input Time, Instant Spectrum, (Averaged) RMS spectrum, (Averaged) Power Spectrum.

2) Averager modes available in this mode:
All.

C. Correlation Mode:

Similar to Dual 1K but optimized for Cross Correlation and Auto Correlation functions. Cross Correlation is defined as Channel A's time history convolved with Channel B's, while Auto Correlation convolves each channel's time history with itself. The result shows the similarity of a signal to the signal it was convolved with delayed by τ (indicated by the CURSOR). For information on interpreting the results, including calculation of "correlation coefficient," please see Table 9-2.

1) Functions available in this mode:
Only Auto Corr, Cross Corr, and Instant Time are recommended.

2) Averager modes available in this mode:
All

D. Probability Mode:

In this mode, the averager averages the occurance of each possible amplitude level. The Probability Density function shows relative probability that a signal was at a certain amplitude. Cumulative distribution function shows the probability that the amplitude of your signal was at or below a value x. For both these functions, the horizontal axis is voltage from -Attenuator setting to +Attenuator setting. Vertical units for CDF are probability, from 0 to 1. PDF is defined as the derivative of CDF by voltage, so its vertical axis goes from 0 to 64/Attenuator setting; units are V^{-1}.

Functions available in this mode:
Cumulative Distribution Function (CDF),
Probability Density Function (PDF), Instant Time.

G-11. 660B FEATURES

A. Text Entry:

Allows four lines of up to 44 characters to be entered, edited, and positioned anywhere on the display. Press the TEXT button (plus TEXT 2, 3, or 4 for those fields) and enter or edit the field using the TEXT entry keypad. The cursor (left-right joystick) controls are used to move the text cursor or, if SHIFT 1, 6 is pressed, to move the text field. For further information, please see Section 18 of the 660B manual.

Text entry was an option on the 660A.

B. Variable Offset and Gain in Phase Displays:

Phase is usually displayed with the top and bottom of the display at plus and minus 180° respectively. For data near ±180°, this can be a disadvantage. Also, small changes in phase may be hard to see.

These problems are solved on the 660B when Phase only(ϕ)is viewed. In this case, the upper gain toggle will "roll" the phase display and the lower gain toggle will increase the gain. With the cursor off, "center/vertical graticule division size" is annotated in degrees. With the cursor on, phase at cursor is annotated.

C. Overlap at Dual Displays:

Dual displays are usually presented one above the other. Pressing the OVLP button will overlap the displays for easier comparison. Pressing OVLP again will return the display to its normal state.

Phase/Mag cannot be overlapped.

D. Self-Test and Diagnostics:

A switch on the 660B's Main Memory board selects either the usual program or the self-test program. The self-test program checks front panel operation, memory, program, operation of all processors and the hardware multiplier, and more. It is fully covered in Section 20 of the 660B manual.

G-12. 660B BUILT-IN OPTIONS

Note:
All the Options covered below are covered in detail in Section 21 of the 660B manual.

A. Excitation Source Option -7:

Before covering Option -7, note that all 660s have a binary noise output on J 110 on the rear panel. This standard noise source is always 0-1 V Peak to Peak, from essentially DC to frequency range setting. It is not a calibrated signal but should be flat within 2 or 3 dB. All 660s also have filtered noise out (J 104) which is the same noise with a notch at approximately 55% of the frequency range. This is essentially a test signal.

Option -7 provides several more advanced features. Its function is selected by the 40 series of Define Aux codes:

40 - Excitation off (Default).
41 - Sine wave out at cursor frequency.
42 - Pseudo-Random Binary Noise.
43 - Periodic Binary Noise.

Output appears on J 109.

1) Sine Wave at Cursor - Sine wave at the cursor frequency. Resolution of .25 Hz, Baseband, or DRT.

2) Pseudo Random Noise - Flat ±3dB of spectral mean across analysis range. When DRT (XPND) is on, noise is Band Limited to concentrate energy inside the analysis window

3) Periodic Noise - Similar to above, but a 1024 or 2048 pt repeating noise pattern, synchronized to data collection.

4) Amplitude of the three functions is variable from 0-9.9 V Peak in 100 mV steps, using 100 to 199 set DEF AUX.

Peak Amplitude = (N - 100) x 100 mV.

B. Digital Expansion or DRT (Digital Range Translation) was covered in Section G-8.C.8. of this document.

C. Octave is a Mode Modifier to the DUAL 1K or CHAnnel A 2K modes. What happens when the Octave button is pushed is controlled by the 200 series of DEF AUX codes as follows:

	# of Passes	1/3 or 1/1	A-weighting
200	1	1/3	OFF
201	2	1/3	OFF
202	1	1/1	OFF
203	2	1/1	OFF
204	1	1/3	ON
205	2	1/3	ON
206	1	1/1	ON
207	2	1/1	ON

Number Passes:
1 Pass computes 5 1/1 octave bands or 15 1/3 octave bands, looks like half a spectrum (left half is zeroed). 2 Pass computes 10 1/1 octave bands or 30 1/3 octave bands. This takes longer and requires automatic switching of frequency range setting.

1) Functions avalable:
INPuT TIME, INSTant TIME, RMS Spec, Power Spec, TF, COH, TM, COP, Cross Spec. Obviously, cross functions are not available in Channel A 2K mode. (Please read the Option -3 part of Section 21 for additional details.

D. Spectrum Calculation Option -8
This option has five major features:

1) Data Editing on data in C.

2) Complex or Scalar Arithmetic.

3) Forward or Inverse FFT on data in C.

4) Special functions, such as damping factor calculation.

5) Force/ Response windows

Note:
"C" is a data buffer used to hold results of Option -8 features.

1) Data Editing:
When viewing C in either the frequency or time domain, one may

a) Insert a value at the cursor: value, SHIFT 2, 5.

b) Draw a straight line between stored cursor locations 1 and 2: SHIFT 2, 6.

Both these functions affect the data in C in a manner consistant with the display format.

REAL - Only Real data affected (CR).
IMAG - Only Imaginary data affected (CI).
REAL & IMAG - Both affected.
MAG or ϕ MAG - Magnitude is changed by multiplying both Real and Imaginary data by the appropriate factor to achieve the desired result. This preserves phase ($\tan^{-1}$ Imag/Real).

2) Complex or Scalar Math:
Equations in TEXT Field 1, written in a simple but powerful character set permit the manipulation of all 660B data buffers. The character set is

Complex Data Sources:

A - Instantaneous A.
B - Instantaneous B.
C - "Complex Math" result buffer.
D - Display Memory buffer.
V - Averaged Cross Spectrum (Buffers 5,6).
T - Transfer function (computed dynamically).

Scalar Data Sources:

Any of the single letters above may be followed by

R - Real part.
I - Imaginary part.

M - Magnitude ($\sqrt{R^2 + I^2}$).

In addition

VA - Averaged Power Spectrum of A.
VB - Averaged Power Spectrum of B.

Two Source Operators

+ - Addition
- - Subtraction
x - Multiplication (SHIFT 2, MULT)
/ - Division (SHIFT 2, DIV)

Single Source Operators:

$\sqrt{\ }$ - Square Root (for example, $\sqrt{VA}$)
- Conjugate (for example, B#)

Other Characters:

)> - Right Parenthesis
(< - Left Parenthesis (may nest 4 sets deep)
: - Equation terminator. All after = comment
, - Comma = numerical separator
. - Decimal point
E - Letter "E" - Exponent follows for floating point notation (E±XX)
0-9 - Numerics

3) Forward or Inverse IFFT on Data in C:

While viewing C, IFFT may be pressed to perform an IFFT on (what is assumed to be) complex spectral information in C. Pressing IFFT again, or exiting view C, will perform an FFT on the contents of C.

Warning:

The FFT is an Approximation to the integral Fourier transform. Non-repetitive time windows or sharp transitions in time will cause errors. All errors will be exaggerated if transformed back and forth several times.

4) Special Functions:

Some data manipulations that could not be entered as equations have been included in Option -8. For example, "SC" computes absolute value of each point of data in Buffer C. To use a special like "SC", the two letter code would be typed into the TEXT 1 Field, verified, and executed.

The most used "special" has been implemented on the front panel; it is calculation of damping factor. This is done as follows:

a) Set CURSOR to -PEAK in TF real below resonance: Press 1, SET, CUR LOC.

b) Set CURSOR to +PEAK in TF real above resonance: Press 2, SET, CUR LOC.

c) Press SHIFT 2, 9 to calculate damping.

For more information, please see Section 21, pages S-23 - S-29, of the 660B manual.

5) Force/Response Windows:

This feature will be covered on pages G-20 and G-21.

An Example:

It is extremely difficult to construct one example to show the use of every feature of Option -8. Therefore, a short scenario is presented below involving several features:

Part 1:

A structure housing a motor has just been constructed and it is necessary to make sure that the structure will not fly apart when the motor is turned on.

Solution:

Impact Testing: Mode = 1K FFT, get TF. Damping factor can be calculated for each resonance. They should be greater than 1.

Part 2:

The transfer function obtained above has an unexpected peak. Furthermore, the impulse response appears predictive. You would like to eliminate the peak and see the impulse response.

Solution:

Edit the data. First, copy the TF into C: While looking at TF, press STO C. (Press 211, SET, DEF AUX so that C is not formatted as power when you view it.) Now press VIEW C. To eliminate the peak, put the CURSOR on one side of it and press 1, SET, CUR LOC, then put the CURSOR on the other side and press 2, SET, CUR LOC. Press SHIFT 2, 6. This does linear interpolation which will eliminate the peak. Now that you have a modified TF, just press IFFT to see the Impulse Response.

Part 3:

You have decided to repeat the above test in Signal Enhancement made. Any signal not synchronized with the impacts will average to zero. After several hundred impacts, you can see from the Average Time Spectra that things look good, but you would like to see a transfer function.

Solution:

Calculate TF.

a) Press "CM" to enable Complex Math. The "TEXT" light comes on.

b) On the text pad, enter "C/D": (Note: the "/" is SHIFT 2, DIV). Turn off TEXT.

c) While displaying the Average Time Spectrum of Channel B, press STO C.

d) While displaying the ATS of Channel A, press STO D.

Note that C now contains the spectrum of Channel B's time averaged signal and D contains Channel A's spectrum. The division will produce a transfer function.

e) Press SHIFT 2, VER. The message "VERIFIED" will appear, signifying that the equation has successfully been translated to executable instructions. All scale factors are determined at this time.

f) Now press SHIFT 2, EXC. If C is being viewed, the result will be seen appearing at the same time as the message "EXECUTED".

C now contains "Synchronous TF" - a function not normally available on a 660B.

Note that the equation was compiled at verification. Thus, if new data were placed in C and D, only SHIFT 2, EXC would have to be pressed to execute the equation again. The equation would not have to be re-entered. Re-verification would not even be necessary unless something affecting scaling (# AVG, Attenuator settings, etc.) had changed.

Part 4:

It is some time later and the motor in the structure is operating. A temporary platform has been set up to permit displacement measurements to be made on the shaft. Unfortunately, the temporary platform is not vibration-free; the displacement probe cannot be kept perfectly still. How can the shaft displacement be measured?

Solution:

Coupling an accelerometer to the displacement probe is preferable. The output of the accelerometer will show movement of the probes. Since acceleration = double integrated = displacement, one would like to subtract the double-integrated output of the accelerometer from the output of the displacement probe. The result is actual shaft displacement; this is what one would like to see.

Now, integration in time is dividing by $j\omega$ in frequency (where $\omega = 2\pi F$). The function can be created and stored in D. Then the equation: "A - ((B/D)/D):" will double integrate B and subtract it from A. (It is assumed that EU/V settings compensate for mismatches between the probes. EU/V are automatically included in scaling form Complex Math equations.)

a) Mode = 1K FFT
   Turn on "CM" (to clear C) and type in the equation: "A - ((B/D)/D):". Turn off TEXT. (Verification can't be done yet since D doesn't contain $j\omega$.) View C imaginary.

b) Assuming the 10,000 Hz range, put the CURSOR on the 1st Cell. Press "157.08 SHIFT 2, 5" (Note: 157.08 = 2π x 25, where 25 is Frequency in Hz for the first cell, as shown by the CURSOR). Press 1, SET, CUR LOC.

c) Put the CURSOR on the rightmost cell. Press "62831.9 SHIFT 2, 5". Press 2, SET, CUR LOC.

d) Press SHIFT 2, 6 to draw a straight line connecting the two created points. The function $j\omega$ has now been created.

e) Press "STO D".

f) SET EXP averaging and "1 SET AVGN", then verify the equation: Press "SHIFT 2, VER"

   Note:
   Equations involving instantaneous data area averaged. They cannot be one-shot executed.

g) Press "START".

Now, as the averager runs, the displacement of the shaft will be seen in C. Exponential averaging with N=1 causes each pass of new data to completely replace the old data. So, the result of your equation is now being watched live, over and over, as it is executed. SUM, DIF, and EXP averaging are permitted into C. Changing the averager mode and average N after verifying an equation will cause the 660B averager buffers and C to average in different modes at the same time.

Note:
Executing an equation each pass of the averager does decrease the real time rate of the analyzer.

Part 5:
The involvement now is in impact testing the shaft to discover its resonances. Unfortunately, the shaft rings like a bell. Its oscillations do not die out by the end of the time window. This violates an assumption of the Fast Fourier Transform: the time window must be periodic. That is, if it's zero on the left, it must be zero on the right. The fact

that the oscillations are truncated on the right of the window introduces errors in the frequency domain.

Solution:
Setting up the 660B's Force and Response windows smoothly (exponential decay) forces the response to nearly zero by the end of the time window. This eliminates the garbage at the expense of some spreading of the spectrum. As an added bonus, when F/R windows are enabled, the Complex Math package provides special data handling which greatly increases the dynamic range of DRT (DRT=XPND).

Here is an example of using F/R windows:

a) You must be in CM. Press "F/R".

b) Look at a captured impulse, set CURSORS 1 and 2 to each side of the impulse (see VIII.9). Do not chop off any part of the impulse.

c) Display Channel B (response). Set CURSOR 3 to the beginning of the exponential window. Set CURSOR 4 to the right of CURSOR 3. This defines 1 time constant for the exponential decay.

d) Set up your averager mode.

e) Type "SW:" into Text Field 1.

f) Verify. This draws the Force and Response windows; It also sets up the commands which implement the use of these windows.

Note:
SW is a canned, live equation. Restrictions about not changing Averager mode, AVG N, attenuator settings, EU/V etc. apply. One must re-verify if something that affects scaling is changed.

This feature is available in baseband or DRT.

Once SW has been verified, the windows are in use. The function "F/R" was only for convenience in setting up the windows. You may press another function. The windows will still be in use until one exits complex math or verifies a different equation. Unlike other live equations, SW affects time data. Its effect is visible on all functions, not just on averaged data.

This ends a brief look at Spectrum Calculation Option -8. The reading of pages S-ϕ to S-32 in Section 21 of the 660B manual is for more information is strongly urged.

G-13. SUMMARY

One should now have a good grasp of what 660 is capable of and how it can be done.

Sections I through VIII told of how to get started in 1K FFT mode and pointed out only the most used functions and features.

Sections IX discussed order tracking.

Section X covered the other 660B modes and their uses.

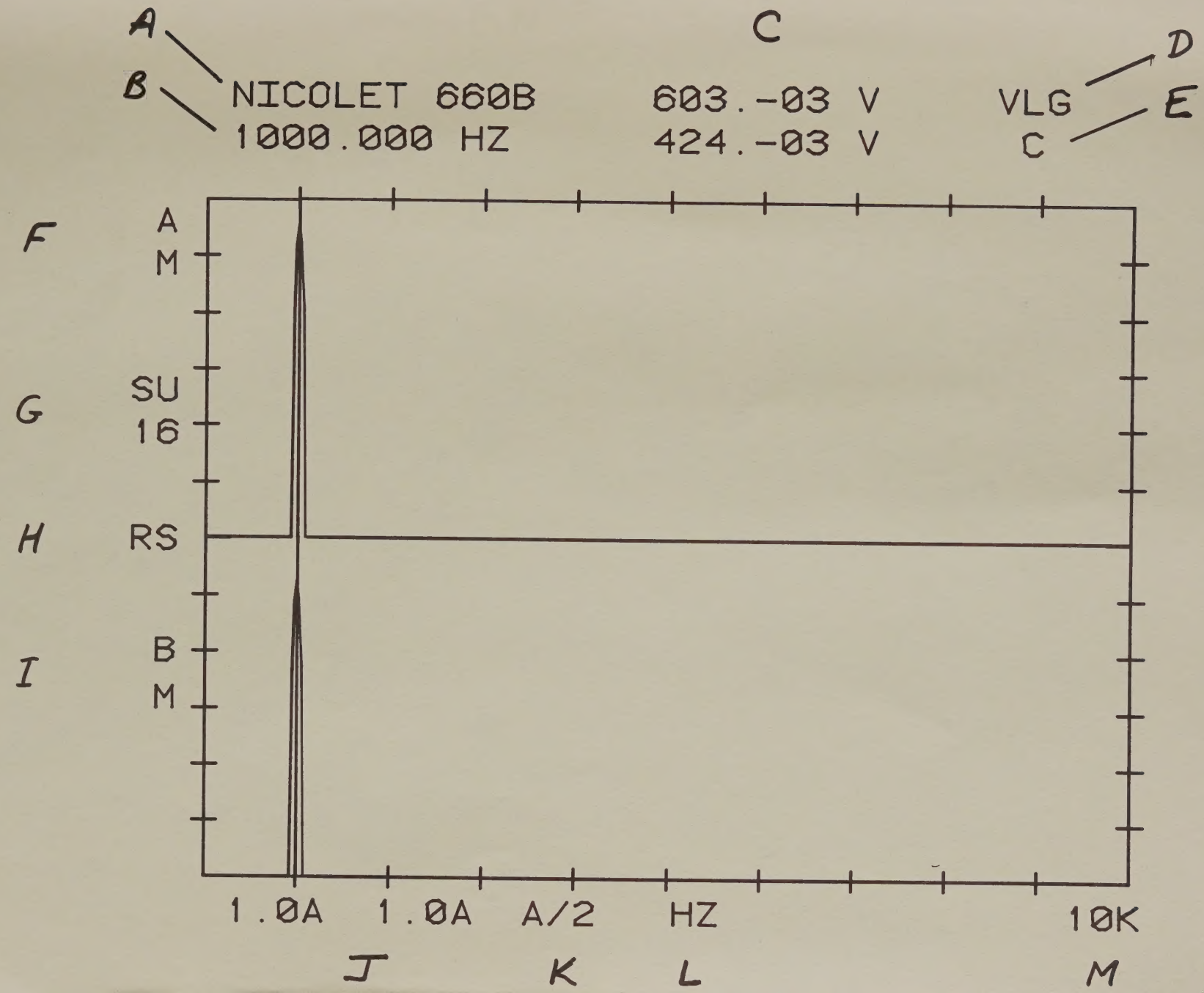
Section XI covered 660B features and Section XII covered the 660B's options.

Sections I-VIII should provide enough information for you to start using a 660 effectively, while Sections IX-XII point out specific features to solve specific problems. If one has read all of this, nearly all of the power of a 660B has been shown. We hope you enjoy using it.

Remember that for more information on any subject, refer to the 660B manual. Some subjects not covered here at all are covered in detail in the 660B manual

(for example, Digital Input/Output is the subject of Section 19).

Thank you for selecting Nicolet equipment for your application.


A
B
NICOLET 660B
1000.000 HZ
C
603.-03 V
424.-03 V
D
VLG
E
C
F
A
M
G
SU
16
H
RS
I
B
M
1.0A
1.0A
A/2
HZ
10K
J
K
L
M